Magnetic Resonance Imaging and Related Technologies

Nuclear magnetic resonance, or NMR, was first applied to medicine in 1977 by Dr. Raymond Damadian of the State University of New York's Downstate Medical Center (Brooklyn,NY). NMR uses a superconducting magnet to align the spin states of hydrogen atoms in cells of the body. When the magnet is turned off and the atoms "relax" to their normal alignment, they emit measurable frequencies. These frequencies are computed, using powerful algorithms, and an image is generated from the results. Protons that are tightly bound within molecules, such as those in bone, emit weak signals, while protons in aqueous environments emit strong ones. Magnetic resonance imaging (MRI) is a direct descendant of NMR.

Strengths

Because MRI produces no ionizing radiation, the entire body can be safely viewed without concern for exposure time. MRI can be augmented with injectable paramagnetic contrast agents such as gadolinium. This method is very useful in brain imaging, and to a lesser extent, in spinal studies. A recently developed investigative method for lung imaging with MRI involves the use of an inhaled gas. MRI has some value in assessing cancer, especially in investigations of disease recurrence, but it is not yet regarded as a reliable screening tool. It is especially good for imaging soft tissues and shows promise for blood flow studies.

Limitations

Despite its promise of accurate, noninvasive imaging, MRI is underutilized. The equipment is very expensive (about $1.5 million per unit cost) and patient throughput is slow. These costs, which are tied to throughput and materials, could be ameliorated with smaller equipment and high-temperature superconductors (i.e., more powerful magnets of smaller size). Patients with cardiac pacemakers and implanted metallic prostheses can't be imaged with this technique. Another limitation is that the tube in which the patient is placed often elicits feelings of claustrophobia, which has turned out to be a surprisingly significant problem. Children usually have to be sedated for MRI. Open magnet units are becoming increasingly available, but at the expense of magnetic field strength, according to one researcher.

MRI, along with X-rays, computerized axial tomography (CAT), and ultrasound, represents a complement in the field of imaging. It images some anatomical features very well, but fails, for instance, in visualization of bone. It is an important method for visualizing tumors in parenchymal tissue, such as the liver. A 0.4 T field MRI machine requires up to an hour to create a good image. While MRI is promising for diagnosis of breast, prostate, and other cancers, its capacity to examine stages of known cancers must be evaluated further before it can be used for detection. Some studies in prostate carcinoma find that MRI misses up to 40 percent of cancers, and has a lower limit of detection of 5 mm.

Cost is an important issue in this era of declining resources and the limits of third-party payers.Reducing the size, but not the strength, of the magnet, and increasing the speed of throughput, would lower the prices of the scans. Helium-based superconductors are expensive, and helium itself boils away rapidly. Hence,high-temperature superconductors would be useful in driving down costs as well. Data upload and download are also time-consuming and inefficient, and comprise a good deal of the preparatory stages for MRI. Hence, software design and the use of parallel processors are valuable to this technology.